MEASUREMENT OF POSSIBLE PESTICIDE EXPOSURE OF AIRPLANE FLAGGERS DURING APPLICATION OF CHLORDIMEFORM AND COTTON FIELD PEST DAMAGE DETECTION PERSONNEL (COTTON SCOUTS) WHO ENTER FIELDS SUBSEQUENT TO APPLICATION

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SUMMARY

Several studies were conducted during July and August, 1982 in California's Imperial Valley, to determine the potential exposure to persons whose jobs might result in their coming into contact with chlordimeform or chlordimeform residue. One of these studies concerned potential flagger inhalation exposure during chlordimeform applications. Breathing zone air samples were taken for 13 flaggers, with one sample result above the limit of detection. This level, obtained while sampling at a rate of 1.90 L/minute, was 3.02 parts per billion (ppb). A separate study was done to determine if residue levels in cotton fields might pose a hazard to persons entering after the 24-hour reentry interval had elapsed. This study was conducted on two cotton scouts, who were responsible for checking insect traps and collecting bolls in each field, to determine the level of Heliothis infestation. Breathing zone, dermal (handwash, patch, and cotton gloves), and urine samples were collected. Detectable levels were found in one breathing zone sample and seven dermal samples. The total estimated dermal exposure was calculated to be 25.65 ug for scout no. 1, and 97.47 ug for scout no. 2. The OBZ (operator breathing zone) air sample from scout no. 1 was below the limit of detection, with 2.90 ppb measured for scout No. 2. All other samples were below the respective limits of detection: air - 1 ppb, urine - 50 ppb, patch samples - .001 ug/cm^2, and handwash - 10 ppb. These exposure levels were considered to be negligible and unlikely to represent any adverse health impact.

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INTRODUCTION

California's Imperial Valley has for many years been plagued with heavy insect pressure, brought on by some of the same factors that create a year-long agricultural production area: fertile soil, an agreeable climate, and the availability of high quality irrigation water. One contributing insect pest, the pink bollworm (Pectinophora gossypiella) was first identified in valley cotton fields in 1965, and was firmly established by 1968. The larvae of this pest destroys the contents of cotton bolls by mining through the seed and the developing lint, causing incomplete boll splitting with rotting lint and seed. Through the late 1960's and early 1970's, valley growers began using increasing amounts of organophosphate compounds in an effort to control growing populations of pink bollworm. However, this increased usage of organophosphates exacted a heavy toll on beneficial insects, inadvertently allowing yet another pest, the cotton bollworm (Heliothis zea), to become a second major threat to cotton by late 1973. To further complicate the increasing pest burden, the tobacco budworm (H. virescens) was identified in the valley in 1975. These young Heliothis larvae feed on the growing points and terminal buds of the cotton plant, while later stages hollow out developing bolls.

Chlordimeform was first introduced as a pesticide for cotton and food crops in 1968, but was not used in the Imperial Valley until 1975. Good control was achieved over both the cotton bollworm and the tobacco budworm using chlordimeform until 1976. At that time, the manufacturer voluntarily withdrew it from the market due to adverse health effects found in their processing plant employees in 1975. Subsequent animal feeding studies exhibited increased cancer development in mice. In 1978, chlordimeform was reintroduced and made available, with recommendations designed to minimize human exposure, to all cotton growing areas except California. At that time it was marketed for use only as an insecticide for cotton, with all food crop uses discontinued. Despite extraordinary measures aimed at eliminating worker exposure, chlordimeform metabolites were found to be measurable in application workers' urine samples. California refused registration because it was believed that these new restrictions were not sufficient to reduce exposure to an acceptable level. Without chlordimeform, Imperial Valley cotton growers turned to pyrethroid insecticides, but because of their broad spectrum nature, large numbers of beneficial insects were again killed. By 1980, it was realized that the effectiveness of pyrethroids decreases with increasing temperature, an important consideration in the desert climate of the Imperial Valley. Growers were using as many as seven different pesticides per application without satisfactory results. Cotton production had dropped from an early 1960's yield of three to four bales per acre to slightly over two bales per acre in the early 1980's.

A change in approach to pest control was decided upon in December, 1981 by the Colorado River Cotton Growers Association, utilizing Integrated Pest Management (IPM) techniques. A cotton pest abatement district (CPAD) was

formed in Imperial County in May 1982, to oversee the proposed IPM program. The basis of this program was a required number of mandatory pheromone applications to disrupt the reproductive cycle of the pink bollworm, thereby reducing the need to treat for this pest until later in the season. Because an effective pesticide was needed to deal with the tobacco budworm and cotton bollworm which would be compatible with the new pheromone program, local growers petitioned the California Department of Food and Agriculture (CDFA) for a Special Local Need (SLN) registration of chlordimeform for the 1982 growing season. CDFA agreed to allow the use of chlordimeform for a maximum of six applications to each cotton field, with provisions that specific worker safety requirements were met. These requirements included the use of protective clothing, protective devices, training sessions, and medical monitoring for all persons involved in chlordimeform applications. One of the protective device requirements for flaggers was the use of a half-face NIOSH/MSHA approved respirator. Various application requirements aimed at the reduction of drift, including a condition that restricted applicators from discharging chlordimeform within 100 feet of a flagger, were also included in the Use Conditions which accompanied the SLN registration (Appendix 1). CDFA's Worker Health and Safety (WH&S) Unit undertook a study to measure the chlordimeform present in the flaggers' breathing zones to determine if the respirator requirement was necessary or could be modified to allow voluntary use.

In 1974, a 48-hour reentry interval was set by the Environmental Protection Agency (EPA), but was later revised to 24-hours after a reevaluation of chlordimeform's dermal toxicity (Zweig et al., 1980). Since persons entering a treated field after 24-hours were not required to wear protective clothing and were not included in the medical monitoring program, there was concern as to what the potential exposure to these persons might be from chlordimeform residue on the plants. WH&S Unit conducted a study on cotton scouts, as these persons spent a considerable amount of time in treated fields. Cotton scouts are responsible for checking insect traps and examining the plants in each field to determine current levels of insect infestation.

MATERIALS AND METHODS

Potential dermal exposure of protected skin areas (body areas covered with clothing) to chlordimeform residue was measured for two scouts. The first scout was monitored while working in one 100-acre field. Patches were pinned to the coveralls of this scout on each thigh, both sides of the upper chest, and on the middle back. The second scout, monitored while working in two fields (field #1 - 106 acres, field #2 - 84 acres), had patches pinned to the bottom of her front shirttail. This location was selected because it was observed that maximum foliage exposure to a person entering a cotton field was likely to occur to the anterior portion of the leg and thigh. The patches on scout number two were changed after work was completed in the first field, prior to entering the second. The patches were made of an outer layer of seven-ounce 65 percent dacron polyester, 35 percent cotton twill, and a middle layer of 100 percent cotton gauze backed by a layer of aluminum foil. Each patch had a pre-marked area of 49 cm^2, which was cut out at the completion of work in each field. The layers were then separated, with the twill layer considered as one sample and the gauze and foil layer considered as another. Matched thigh, chest, and shirttail patch layers were placed together in glass jars. Levels of chlordimeform residue on the scouts' hands and forearms were measured by obtaining pre- and post-work washes, using 250 mL of distilled water. In addition to this, the first scout also wore absorbent cotton gloves while working in the field. These were put on after the pre-work handwash was obtained, and removed just prior to taking the post-work wash. All patch, handwash, and cotton glove samples were stored on ice in glass jars sealed with foil lined lids.

Potential inhalation exposure of cotton scouts was monitored using a DuPont Model P4000 portable air pump. Air was sampled in the operator's breathing zone (OBZ) at a rate of 2 liters per minute, using 0.3 um pore size 37 mm glass fiber filters, backed by XAD resin tubes (SKC, Inc.). Using this sequential arrangement of sampling media, it was theoretically possible to collect both chlordimeform mist and vapor. Upon completion, both the tubes and the filters were capped and placed in a zip-lock plastic bag.

Three urine samples were collected in 125 mL polypropylene bottles from the second scout at different times following her work in the cotton field: The first voiding after leaving the treated field, 16 hours post exposure, and 20 hours post exposure.

Potential inhalation exposure only was monitored for flaggers. Seven flaggers were monitored at a low flow rate (0.21 to 0.23 mL per minute), using XAD resin tubes as the collection media. Four other flaggers were measured at a low flow rate, using XAD resin tubes in series with 0.3 um pore size 37 mm glass fiber filters. OBZ samples were collected from two additional flaggers, using the above media, with the only difference being a higher flow rate (2L/minute). Low flow rate samples were obtained using an MSA model C210 portable air pump, while DuPont model P4000 pumps were used for higher flow rate sampling.

All samples were stored on ice until they reached the CDFA laboratory in Sacramento. Analysis for chlordimeform residues was done using methods which are held as confidential information by the manufacturer. Levels of detection are urine - 50 ppb, air - 1 ppb, handwash - 10 ppb, and patch - 0.001 ug/cm^2.

RESULTS

Results of experimental data are summarized in Tables 1 through 3.

Table 1 shows sampling results obtained during the monitoring of the cotton scouts. Patch, handwash, glove, air, and urine sample results are all included in this table.

Table 2 provides information on the potential dermal exposure of the cotton scouts to chlordimeform residue. Values expressed under "Concentration of Chlordimeform Residue" are the amounts of the chemical found on the cloth and gauze layers during the monitoring period. These values, express in ug/ total sample, are the same as those in Table 1. Asterisked values listed under "Estimated Dermal Exposure" are calculated using the fact that each patch is 49 cm^2, and assuming the surface area of the average body is as follows: (DuBois and DuBois, 1916; Berkow, 1931.)

head, face, and neck	1,110 cm^2
anterior trunk	3,700 cm^2
posterior trunk	3,300 cm^2
arms and forearms	2,498 cm^2
anterior thighs, legs, feet	3,515 cm^2
posterior thighs, legs, feet	3,515 cm^2

Since all patches were placed on portions of the body which are covered with clothing during work, values of chlordimeform residue found on gauze layers estimate the amount of the chemical that would penetrate one layer of clothing. No calculations are done on handwash and cotton glove data. The total estimated dermal exposure is the sum of calculated gauze residue levels and handwash/glove values.

Table 3 shows the potential inhalation exposure of flaggers to chlordimeform during application. A total of 13 flaggers were monitored, 11 using a low flow rate and two at a higher rate.

DISCUSSION AND CONCLUSIONS

A cotton scout study was undertaken to estimate the exposure to persons entering a chlordimeform-treated cotton field after the 24-hour reentry interval had elapsed. Persons entering a treated field after this period were not required to wear the protective clothing or devices stated in the chlordimeform use conditions which accompanied the SLN registration, and were not included in the medical monitoring program.

Because of uncertainty as to where the maximum exposure to foliage would be, patches were placed on the first scout's back, chest, and thighs. All patch samples for this scout were below the limit of detection. After observing the first scout, it was determined that the maximum exposure to protected skin areas was most likely to occur to the anterior portion of the leg and thigh. Because of this, patches on the second scout were placed only at anterior thigh level. The outer cloth layer of these patches had residue levels of 0.046 ug/cm^2 after working in field #1, and 0.0074 ug/cm^2 after field #2. The middle layer of the patch from field #2 was below the limit of detection, while chlordimeform residue on the middle layer from field #1 was 0.017 ug/cm^2. Handwash samples obtained from the scouts prior to entering their first field were both below the limit of detection. Wash samples done after work was completed showed 1.75 ug for scout #1; no chlordimeform residue was detected from scout #2. Another set of handwashes was obtained from scout #2 prior to and after working in the second field. The pre-work sample had 18.50 ug chlordimeform present, while the post-sample showed 18.00 ug.

Cotton gloves, worn by scout #1, had 23.90 ug chlordimeform present. Previous studies (Durham and Wolfe, 1962; Davis, 1980) have indicated that the use of absorbent gloves might result in high estimates of exposure to the hands, as gloves might tend to absorb much more liquid than could be expected to adhere to flesh.

Only one OBZ sample obtained from the monitored cotton scouts had a chlordimeform residue level above the limit of detection. In this case, 2.90 ppb chlordimeform was found in the glass fiber filter on the second scout after working in two fields for a total of 16 minutes. Previous studies (Durham, et al., 1972; Feldman and Maibach, 1974) have indicated that dermal exposure to pesticides is generally of much greater concern in terms of health effects than is inhalation exposure. The total estimated dermal exposure for scout #1 was 25.65 ug, while the level for scout #2 was 97.47 ug.

Chlordimeform metabolites appear in the urine shortly after exposure, with approximately 75 percent of the absorbed material excreted within 24 hours of the onset of exposure (Kurtz, et al., 1983). All urine samples from scout #2 were below the limit of detection. No urine samples were obtained from scout #1.

This study has shown that there is a measurable potential exposure to chlordimeform for cotton scouts or other workers that might enter chlordimeform treated fields after the reentry period has expired. There was no measurable chlordimeform vapor present. The airborne chlordimeform collected on the particulate filter of scout #2 may have been due to dust or plant material dislodged by the scout while making her way through the field. Contact with treated foliage appears to be the major source of potential exposure. Results from this study suggest that cotton scouts and others who might enter chlordimeform treated fields should avoid contact with foliage, or be supplied with clean gloves and coveralls, which should provide adequate protection.

Flaggers were monitored to determine what their potential inhalation exposure might be during chlordimeform applications. Only one of the 13 flaggers studied had chlordimeform levels above the limit of detection. 3.02 ppb chlordimeform was found on the glass fiber filter after sampling a total of 258.40 L air at a rate of 1.90 L/minute. There appears to be no measurable chlordimeform vapor present. Because of the low concentrations of chlordimeform found in the flaggers' OBZ samples, it is believed that future applications of this chemical could be flagged without the use of respirators, provided the flagger is protected from the mist. The inhalation exposure potential to chlordimeform was negligible and without human health significance under the conditions of this study.

TABLE 1
COTTON SCOUT SAMPLING RESULTS

	SCOUT #1	SCOUT #2	
		Field #1	Field #2
Air-XAD Resin Tube	None Detected (ND) 40 L Air Sampled	Same XAD Tube and Glass Fiber Filter to Monitor in Both Fields	ND
Air-glass fiber filter	ND, 40 L air sampled		2.90 ppb, 32 L air sampled
Patch-back outer layer middle layer (ug/patch)	ND ND		
Patch-chest outer layer middle layer (ug/patch)	ND ND		
Patch-thigh level outer layer middle layer (ug/patch)	ND ND	4.6 1.7	0.73 ND
Handwash - Before work	ND	ND	18.50 ug
Handwash - after work	1.75 ug	ND	18.00 ug
Cotton gloves	23.90 ug		
Urine	—	1st voiding after exposure: ND 16 hours post exposure: ND 20 hours post exposure: ND	

TABLE 2
COTTON SCOUT #1 DERMAL EXPOSURE CALCULATIONS

Sample Source	Concentration of Chlordimeform Residue (ug/Sample)	Estimated Dermal Exposure (ug)
Back patch:		
outer layer	None Detected (ND)	-0-*
middle layer	ND	-0-*
Chest patch:		
outer layer	ND	-0-*
middle layer	ND	-0-*
Thigh patch:		
outer layer	ND	-0-*
middle layer	ND	-0-*
Handwash:		
before work	ND	-0-
after work	1.75	1.75
Cotton gloves	23.90	23.90
Total estimated Dermal Exposure		25.65 ug

*These figures are calculated using the following factors:
(1) A patch is 49 cm^2
(2) Surface areas of the body portions monitored are estimated to be:
Chest - 3,700 cm^2
Back - 3,300 cm^2
thighs and legs (anterior) and feet - 3,515 cm^2

COTTON SCOUT #2 DERMAL EXPOSURE CALCULATIONS

Sample Source	Concentration of Chlordimeform Residue (ug/Sample)	Estimated Dermal Exposure (ug)
Front shirttail patches (thigh level)		
Field #1:		
outer layer	4.60	
middle layer	1.70	60.97*
Field #2:		
outer layer	0.73	
middle layer	ND	-0-*
Handwash		
field #1:		
before work	ND	-0-
after work	ND	-0-
field #2:		
before work	18.50	18.50
after work	18.00	18.00
Total estimated Dermal Exposure		97.47 ug

*These figures are calculated using the following factors:

(1) A patch is 49 cm^2

(2) The surface area of the anterior portion of the thighs, feet, and legs is estimated to be 3,515 cm^2

TABLE 3
FLAGGER BREATHING ZONE SAMPLING RESULTS

Flagger	Flow Rate (L/minute)	Sample Period (minutes)	Total Air Volume Sampled (L)	Sampling Media XAD-4 Resin tube	Glass Fiber Filter	Concentration of Chlordimeform (ppb)
1	.23	105	24.15	X		ND
2	.21	105	22.05	X		ND
3	.22	110	24.20	X		ND
4	.22	110	24.20	X		ND
5	.23	100	23.00	X		ND
6	.22	100	22.00	X		ND
7	.23	75	17.25	X		ND
8	.21	45	9.45	X		ND
					X	ND
9	.22	45	9.90	X		ND
					X	ND
10	.16	284	45.44	X		ND
					X	ND
11	.22	319	70.18	X		ND
					X	ND
12	1.90	115	218.50	X		ND
					X	ND
13	1.90	136	258.40	X		ND
					X	3.02

Chlordimeform Use Conditions (section pertaining to flagging)

I. Flaggers

A. The following flagging methods are acceptable:

1. Use of an electronic (Loran-type) guidance system without using any human flaggers; or

2. Flagging from a closed vehicle.

a. This vehicle shall be equipped with an auxiliary air conditioner that does not draw ambient air into the passenger compartment.

b. The person in the vehicle shall not open the windows during application; and

c. She/he shall wear clean one-piece long sleeve cloth coveralls daily.

3. A human flagger may be used without a vehicle under the following conditions:

a. One-piece longsleeve cloth coveralls;

b. Washable cloth hat (tight weave, total circumference brim);

c. Waterproof boots;

d. Cloth gloves shall be worn;

e. A 1/2-face respirator NIOSH/MSHA approved; and

f. On each pass over the treatment area, chlordimeform shall not be discharged within 100 feet of a flagger. The buffer zone shall be treated only after the flagger is completely and safely away from the field.

4. Other systems of protection may be approved by written permission of the commissioner and director.

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